

WHAT IS CLAIMED IS:

1. A positive electrode for a lithium-sulfur battery comprising:
a positive active material selected from the group consisting of elemental sulfur (S_8), a sulfur-based compound, and mixtures thereof;
5 a conductive material;
a binder; and
an inorganic additive with a particle size D (v, 50%) of 5,000 nm or less and that is insoluble in an electrolyte comprising a non-aqueous organic solvent.
- 10 2. The positive electrode of claim 1, wherein the inorganic additive is selected from the group consisting of metal oxides, metal sulfides, and mixtures thereof.
- 15 3. The positive electrode of claim 2, wherein the metal is at least one selected from the group consisting of V, Al, Zr, and Ti.
4. The positive electrode of claim 1, wherein the inorganic additive is at least one selected from the group consisting of V_2O_5 , ZrO_2 , and TiS_2 .
5. The positive electrode of claim 1, wherein the inorganic additive has a particle size D (v, 50%) of 1 to 5,000 nm.
- 20 6. The positive electrode of claim 5, wherein the inorganic additive has a particle size D (v, 50%) of 5 to 4,000 nm.
7. The positive electrode of claim 6, wherein the inorganic additive has a particle size D (v, 50%) of 10 to 3,000 nm.
- 25 8. The positive electrode of claim 1, wherein the inorganic additive is present in an amount of 1 to 50 wt%.
9. The positive electrode of claim 1, wherein the inorganic additive is present in an amount of 2 to 25 wt%.
10. The positive electrode of claim 1, wherein the inorganic additive is present in an amount of 3 to 20 wt%.
11. The positive electrode of claim 1, wherein the sulfur-based compound is selected from the group consisting of Li_2S_n , wherein $n \geq 1$,) organic-sulfur compounds, and carbon-sulfur polymers having the formula $(C_2S_x)_n$, where $x=2.5$ to 50 and $n \geq 2$.
- 30 12. The positive electrode of claim 1, wherein the positive electrode further comprises a coating layer, the coating layer comprising a polymer, an inorganic material, or a mixture thereof.

13. The positive electrode of claim 12, wherein the coating layer comprises a polymer selected from the group consisting of polyvinylidene fluoride, copolymers of polyvinylidene fluoride and hexafluoropropylene, poly(vinyl acetate), poly(vinyl butyral-co-vinyl alcohol-co-vinyl acetate), poly(methylmethacrylate-co-ethyl acrylate), polyacrylonitrile, polyvinyl chloride-co-vinyl acetate, polyvinyl alcohol, poly(1-vinylpyrrolidone-co-vinyl acetate), cellulose acetate, polyvinyl pyrrolidone, polyacrylate, polymethacrylate, polyolefin, polyurethane, polyvinyl ether, acrylonitrile-butadiene rubber, styrene-butadiene rubber, acrylonitrile-butadiene styrene, a sulfonated styrene/ethylene-butylene/styrene triblock copolymer, polyethylene oxide, and mixtures thereof.

10 14. The positive electrode of claim 12, wherein the coating layer comprises an inorganic material selected from the group consisting of colloidal silica, amorphous silica, surface-treated silica, colloidal alumina, amorphous alumina, tin oxide, titanium oxide, vanadium oxide, titanium oxide (TiS_2), zirconium oxide (ZrO_2), iron oxide, iron sulfide (FeS), iron titanate ($FeTiO_3$), barium titanate ($BaTiO_3$), and mixtures thereof.

15 15. The positive electrode of claim 12, wherein the coating layer comprises conductive carbon.

16. A positive electrode for a lithium-sulfur battery comprising:
a positive active material selected from the group consisting of elemental sulfur (S_8), sulfur-based compounds, and mixtures thereof;

20 a conductive material;

a binder; and

an inorganic additive comprising one or more metal oxides or metal sulfides.

17. The positive electrode of claim 16, wherein the metal is at least one selected from the group consisting of V, Al, Zr, and Ti.

25 18. The positive electrode of claim 16, wherein the inorganic additive is Al_2O_3 .

19. The positive electrode of claim 16, wherein the inorganic additive has a particle size D (v, 50%) of 35,000 nm or less.

20. The positive electrode of claim 19, wherein the inorganic additive has a particle size D (v, 50%) of 1 to 35,000 nm.

30 21. The positive electrode of claim 20, wherein the inorganic additive has a particle size D (v, 50%) of 3 to 10,000 nm.

22. The positive electrode of claim 21, wherein the inorganic additive has a particle size D (v, 50%) of 5 to 5,000 nm.

23. The positive electrode of claim 16, wherein the inorganic additive is present in an amount of 1 to 50 wt%.

24. The positive electrode of claim 23, wherein the inorganic additive is present in an amount of 2 to 25 wt%.

5 25. The positive electrode of claim 24, wherein the inorganic additive is present in an amount of 3 to 20 wt%.

26. The positive electrode of claim 15, wherein the sulfur-based compound is selected from the group consisting of Li_2S_n , wherein $n \geq 1$, organic-sulfur compounds and carbon-sulfur polymers of the formula $(\text{C}_2\text{S}_x)_n$ wherein $x=2.5$ to 50 and $n \geq 2$.

10 27. The positive electrode of claim 16, wherein the positive electrode further comprises a coating layer, the coating layer comprising a polymer, an inorganic material or a mixture thereof.

15 28. The positive electrode of claim 27, wherein the coating layer comprises a polymer selected from the group consisting of polyvinylidene fluoride, copolymers of polyvinylidene fluoride and hexafluoropropylene, poly(vinyl acetate), poly(vinyl butyral-co-vinyl alcohol-co-vinyl acetate), poly(methylmethacrylate-co-ethyl acrylate), polyacrylonitrile, polyvinyl chloride-co-vinyl acetate, polyvinyl alcohol, poly(1-vinylpyrrolidone-co-vinyl acetate), cellulose acetate, polyvinyl pyrrolidone, polyacrylate, polymethacrylate, polyolefin, polyurethane, polyvinyl ether, acrylonitrile-butadiene rubber, styrene-butadiene rubber, acrylonitrile-butadiene styrene, 20 a sulfonated styrene/ethylene-butylene/styrene triblock copolymer, polyethylene oxide, and mixtures thereof.

25 29. The positive electrode of claim 27, wherein the coating layer comprises an inorganic material selected from the group consisting of colloidal silica, amorphous silica, surface-treated silica, colloidal alumina, amorphous alumina, tin oxide, titanium oxide, vanadium oxide, titanium oxide (TiS_2), zirconium oxide (ZrO_2), iron oxide, iron sulfide (FeS), iron titanate (FeTiO_3), barium titanate (BaTiO_3), and mixtures thereof.

30. The positive electrode of claim 27, wherein the coating layer comprises conductive carbon.